

Level of Knowledge, Attitude and Practice of Night Market Food Outlet Operators in Kuala Lumpur Regarding the Usage of Repeatedly Heated Cooking Oil

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SUMMARY

Consumption of repeatedly heated oil can be detrimental to health. The objective of this study was to determine the level of knowledge, attitude and practice of night market food outlet operators in Kuala Lumpur regarding the usage of repeatedly heated cooking oil. The quality of cooking oil was also investigated. A cross-sectional study involving pre-tested questionnaire was undertaken in April 2009. The questionnaire was designed as a tool to collect data from the respondents (n=100) by face-to-face interview. The results showed that majority of respondents had only moderate (53.0%) or low (18.0%) level of knowledge regarding this issue. Most respondents (67.0%) agreed that it is not a good practice. The majority (69.0%) agreed that the usage of repeatedly heated cooking oil is detrimental to health. Despite that, most respondents (63.0%) admitted that they had used cooking oil repeatedly. Most (62.0%) of the cooking oil samples taken from the night market food outlets were considered fit for human consumption. In conclusion, the level of knowledge of night market food outlet operators in Kuala Lumpur regarding this issue needs to be improved in order to ensure the safety of fried food purchased from such establishments.

KEY WORDS:

Repeatedly heated cooking oil, deep frying, night market food outlet operators, Peroxide Value, health, knowledge, attitude and practice

INTRODUCTION

It is a common practice in the household or in the commercial sector to use the same frying oil repeatedly to save cost. The oil is discarded only when it becomes foamy, emits bad odour or when the colour turns dark¹. Deep frying is a frying process where the food is completely immersed in the frying oil at temperatures of between 160-190°C in the presence of air and moisture. Chemical reactions such as oxidation, hydrolysis and thermal polymerization occur when cooking oil is heated during the deep frying process². The quality of oil deteriorates with increased length of frying time due to the accelerated formation of oxidized and polymerized lipid species in the frying medium. Repeatedly heated oil can cause changes in physical appearance of the oil such as increased viscosity, darkening in color, increased

foaming and decrease in smoke point of the oil. If the physico-chemical properties of cooking oil deteriorate, the oil must be discarded because it can prove to be harmful for human consumption. The rate of formation of cooking oil decomposition products depends on the type of food being fried, the type of oil used and the design of the fryer².

The consumption of repeatedly heated cooking oil is unhealthy. In the process of frying food, cooking oil is often exposed to high temperatures for long periods of time. This practice generates lipid peroxidation products that may be harmful for human health³. The presence of excess polar compounds in repeatedly used frying oil has been associated with increased risk of developing hypertension⁴. Consumption of repeatedly heated cooking oil might increase the risk of developing atherosclerosis. Lipid peroxidation products induce oxidative stress in endothelial cells, resulting in endothelial dysfunction that could eventually lead to the formation of atherosclerosis⁵. Consumption of repeatedly heated cooking oil is also associated with increased total serum lipid and low density lipoprotein (LDL) levels⁶. Moreover, thermally oxidized lipids enhance peroxidation of membrane macromolecules, contributing to their mutagenicity and genotoxicity which could potentially lead to carcinogenesis⁷⁻⁹.

A recent study conducted in our department showed that consumption of soy oil that has been repeatedly heated might cause an increase in lipid peroxidation and LDL in ovariectomized female rats (which simulates a post-menopausal state with oestrogen deficiency in humans)¹⁰. The results of that particular study suggested that repeated heating gradually diminished the health-protective effects afforded by soy cooking oil and may contribute to the pathogenesis of atherosclerosis in post-menopausal women¹⁰. Another recent study conducted in our department showed that consumption of repeatedly heated cooking oil resulted in increased blood pressure and necrosis of cardiac tissues in experimental rats¹¹. The increase in blood pressure due to consumption of repeatedly heated cooking oil might be due to quantitative changes in endothelium dependent and independent factors including enzymes directly involved in the regulation of blood pressure¹².

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The quality of oil used for frying food is affected by frying temperature, the cleanliness of cooking utensils, turnover of cooking oil used for frying, the filtering process as well as the use of filtering agents, amongst others^{13,14}. Intermittent heating and cooling causes greater deterioration of cooking oil than continuous heating alone, due to increased oxygen solubility in the oil when it cools down from the high frying temperature¹⁵. Furthermore, the oil degradation products content in cooking oil increases with repeated number of fryings¹⁶. Studies done to gauge food outlet operators' awareness on the dangers of consuming repeatedly heated cooking oil are lacking. A study conducted in New Zealand showed that only 8% of independent food outlet operators had formal training in deep frying practices compared with 93% of chain (franchise) food operators¹⁷. That study also revealed that 65% of food outlet operators surveyed changed the oil used for frying at least once a week, however, many of them relied on late signs of oil degradation (change in oil colour and smoke emanating from heated oil) in their decision to replace an old batch of oil with a new one.

Malaysians consume a considerable amount of fried food bought from roadside outlets, night market food outlets and restaurants. Consequently, the food frying practices of the operators of these establishments could have big influence on the general health of the Malaysian population. To our knowledge, no attempt has been made to evaluate the knowledge, attitude and practice of food outlet operators in Malaysia regarding the usage of repeatedly heated cooking oil. Therefore, this study aims to determine the level of knowledge, attitude and practice of night market food outlet operators in several areas within Kuala Lumpur regarding the usage of repeatedly heated cooking oil. The quality of cooking oil that was used by the night market operators to fry food was also determined by measuring the Peroxide Value (PV) of the sampled oils.

MATERIALS AND METHODS

Study design

This cross-sectional study was conducted throughout the month of April 2009 at night markets in twenty (20) selected locations in Kuala Lumpur.

Study population

The study population is made up of night market (pasar malam) food operators in Kuala Lumpur. The study involved convenience sampling of 100 night market food operators at 20 selected locations in Kuala Lumpur (5 night market operators per selected area; n=100). These locations include areas such as Wangsa Maju, Keramat, Bandar Tun Hussein Onn, Sentul, Taman Tun Dr. Ismail, Kepong, Titiwangsa, Bandar Tun Razak, Pantai Dalam, Kampung Baru, Bandar Sri Damansara, Jalan Kuchai Lama, Sri Petaling, Bukit Jalil, Setiawangsa, Bangsar, Taman Maluri, Kampung Pandan, Gombak and Jalan Klang Lama. These locations were chosen because they represent typical residential areas within Kuala Lumpur. The inclusion criteria were night market food outlet operators who are citizens of Malaysia residing in Kuala Lumpur aged 18 and above, the night market food outlet chosen must sell deep fried food and the operators of the outlets chosen for the interview must have experience in using as well as handling cooking oil for deep frying. Deep

frying involves the immersion of food in cooking oil at temperatures of between 160-190°C in the presence of air and moisture. Examples of deep fried food that can be found in a typical Malaysian night market (pasar malam) include potato chips (French fries), goreng pisang (fried banana fritters), goreng ubi (fried tubers such as fried sweet potato, yam or cassava fritters), keropok lekor, fried fish cakes, fried chicken and fried sausages. Night market food outlet operators were excluded if they did not satisfy these criteria. Informed consent was obtained from all participating subjects.

Questionnaires

Validated standardized questionnaires were written in English and Malay. The survey was carried out within 4 weeks in April 2009. Relevant data was collected from the respondents by individual face-to-face interview, by adhering strictly to the questions found in the standardized, validated questionnaires. The questions were divided into three parts. The respondents were required to provide demographic data such as age, sex and educational level in the first part of the questionnaire. The knowledge on the usage of repeatedly heated cooking oil was evaluated in the second part of the questionnaire. In this part, the respondents were asked whether the usage of repeatedly heated cooking oil is a good practice, whether the quality of oil used for frying remains the same regardless of how many times the oil is reheated, whether there is loss of nutrients in the repeatedly heated cooking oil, whether the different types of cooking oil produce different by-products if repeatedly heated, whether consumption of food that was fried with repeatedly heated cooking oil is healthy and the health complication that can arise through consumption of such food. The attitude and practice of usage of repeatedly heated cooking oil were evaluated in the third part of the questionnaire. In this part, we mostly assumed that the attitude of the night market food outlet operators towards the usage of repeatedly heated cooking oil was reflected in their practice of using cooking oil. The respondents were asked if they used cooking oil repeatedly when they deep fry food such as potato chips (French fries), goreng pisang (banana fritters), goreng ubi (fried tubers such as fried sweet potato, cassava or yam fritters), fried keropok lekor, fried fish cakes, fried chicken and fried sausages, which are typical deep fried offerings commonly found in Malaysian night markets. If they did not re-use the oil for subsequent sessions of deep frying, they were again asked for their reasons. If the respondents replied that they had indeed used cooking oil repeatedly for subsequent deep frying sessions, they were again asked how many times the oil was used before discarded. The respondents were also asked whether they follow any guidelines when they deep fry food, for example, if they control the oil temperature during frying and how long the cooking oil was used for deep frying before it was topped-up, replaced and discarded. We also asked the food outlet operators whether they would like to obtain more information about this subject matter, which include the proper procedures for deep frying food, as well as the detrimental effects of consuming food that has been fried in repeatedly heated cooking oil. The respondents attitude in seeking information about the usage of repeatedly heated cooking oil were also tested by asking them if they had ever heard that reusing and reheating cooking oil repeatedly is not a good practice, either through the newspapers, magazines

and other mass media such television, radio and the internet. The questionnaires were pre-tested on 10 food outlet operators in Universiti Kebangsaan Malaysia (UKM) and were validated by the UKM Ethics Committee before the official survey was performed. Based on the pre-test feedback and also from comments made by the UKM Ethics Committee, some of the original questions in the original questionnaire had to be modified for the actual study. All data collected was made anonymous, stored and controlled by the authors.

Evaluation on the level of knowledge about repeatedly heated cooking oil amongst night market food operators

In order to evaluate the level of knowledge regarding the topic, each respondent was asked seven (7) questions in the second part of the questionnaire. A score of 1 was given if they answered a question correctly, otherwise nil (0) mark was given. However, for Question No. 6 (Will repeatedly heated cooking oil used for frying cause bad effects to our health?), if the respondents had chosen "No" or "Not Sure" as the answer, they did not have to attempt the last question (Question No. 7), so the total knowledge score would be '6' for some and '7' for others. The scores obtained from questions in the second part was then summed up in order to obtain the respondents' knowledge scores and subsequently classified into three levels of knowledge according to the total scores obtained i.e. low (0-2), moderate (3-5) or high (6-7).

Collection of frying oil samples from night market food operators

Samples of frying oils were obtained from 5 food outlets in each of the 20 night markets situated in the chosen areas within Kuala Lumpur as mentioned previously (100 different oil samples collected altogether). The oils were collected when the night market operators were in the middle of their deep frying sessions, which was around 7pm to 8pm. Most night market operators start their deep frying sessions at around 5pm and they finish at around 10pm. The volume of each oil sample is at least 50 ml and the oil collected from each food outlet was stored individually in different 100 ml dark-coloured glass sample bottles (n=100). The oil samples were then taken into the laboratory, chilled and then frozen (-20°C) as soon as possible until analysis.

Determination of Peroxide Value (PV) of frying oil samples

The PV of frying oil samples was determined according to the American Oil Chemists' Society (AOCS) standard titration method (official method Cd 8-53)¹⁸. Peroxide value was expressed as milliequivalents of active oxygen per kilogram of oil sample, mEqO₂/kg.

Statistical analysis

Data was analyzed using SPSS software (version 12, SPSS Inc, Chicago). Descriptive statistics, including frequencies and percentages, were calculated for relevant items obtained from the questionnaire. The Chi-Square test was performed to determine (1) the association between the night market food outlet operators level of knowledge and their attitude and practice regarding usage of repeatedly heated cooking oil, (2) the association between their attitude and practice regarding usage of repeatedly heated cooking oil and the PV of cooking oil samples taken from them, (3) the association between their educational status and level of knowledge with regards to the usage of repeatedly heated cooking oil and (4) the

association between different income areas (low, middle and high) and the PV of oil samples taken from night markets in those areas. One-way ANOVA with Tukey HSD post-hoc test was performed to determine the difference between PV of oil samples obtained from different areas of Kuala Lumpur. A p-value of < 0.05 was considered to be statistically significant.

Ethical consideration

The Human Research and Ethics Committee, Universiti Kebangsaan Malaysia, has reviewed and approved this study with respect to the methodology and ethical considerations.

RESULTS

Demographic data

A total of 100 respondents consisting of night market food operators in Kuala Lumpur were enrolled in this survey. The age of respondents ranged from 19 to 73, with a mean of 41.1 ± 12.9. The largest number of respondents (19) was in the 35-39 age group, whereas the smallest number of respondents (2) was in the 65-69 age group (Table I). A slight majority of the respondents were females (57.0%). Most of the respondents were Malays (91.0%). The majority of the respondents' educational level was up to secondary school (high school) level (56.0%). All night market food operators interviewed claimed to use palm oil for frying food (100%). Other details of the demographic data are shown in Table I.

Knowledge of the usage of repeatedly heated cooking oil

More than half of the 100 respondents (67.0%) did not agree that the usage of repeatedly heated cooking oil is a good practice. The majority of respondents (70.0%) disagreed that the quality of cooking oil remains the same regardless of how many times it has been re-used for frying. Most of the

Table I: Demographic data of Kuala Lumpur night market food outlet operators who took part in the study

Data	Numbers (Percentage)
Total number of subjects (n)	100 (100)
Gender :	
Male	43 (43.0)
Female	57 (57.0)
Race :	
Malay	91 (91.0)
Chinese	2 (2.0)
Indian	7 (7.0)
Age :	
<25	6 (6.0)
25-29	10 (10.0)
30-34	13 (13.0)
35-39	19 (19.0)
40-44	15 (15.0)
45-49	8 (8.0)
50-54	10 (10.0)
55-59	7 (7.0)
60-64	6 (6.0)
65-69	2 (2.0)
>70	4 (4.0)
Respondents' educational level :	
None	6 (6.0)
Primary school	24 (24.0)
Secondary school	56 (56.0)
Diploma	9 (9.0)
Degree & above	5 (5.0)
Type of oil used for frying :	
Palm oil	100 (100)

Table II: Respondents' knowledge of the usage of repeatedly heated cooking oil

Questions	Numbers (Percentage)
1. Usage of repeatedly heated cooking oil for frying food is a good practice as it saves cost and there is no side effect.	Total n=100
Agree	30 (30.0)
Disagree	67 (67.0)
Not sure	3 (3.0)
2. The quality of oil used for frying will remain the same regardless of how many times the oil is reheated.	Total n=100
Agree	25 (25.0)
Disagree	70 (70.0)
Not sure	5 (5.0)
3. We can use the oil for many times and discard it only when it turns dark.	Total n=100
Agree	22 (22.0)
Disagree	71 (71.0)
Not sure	7 (7.0)
4. There will be loss of nutrients in the repeatedly heated cooking oil used for frying.	Total n=100
Agree	45 (45.0)
Disagree	12 (12.0)
Not sure	43 (43.0)
5. The type of cooking oil does not influence the type of by-products produced from the repeatedly heated cooking oil.	Total n=100
Agree	24 (24.0)
Disagree	23 (23.0)
Not sure	53 (53.0)
6. Will repeatedly heated cooking oil used for frying cause bad effects to our health?	Total n=100
Yes	69 (69.0)
No	12 (12.0)
Not sure	19 (19.0)
7. For the 69 respondents who answered "yes" to the above question (question no. 6), what type of disease do they associate with the consumption of repeatedly heated cooking oil?	Total n=69
Gout	2 (2.9)
Tuberculosis	2 (2.9)
Diabetes	0 (0)
Hypertension	22 (31.9)
Cancer	43 (62.3)

Table III: Respondents' attitude and practice regarding the usage of repeatedly heated cooking oil

Questions	Numbers (Percentage)
1. Do you use cooking oil repeatedly for frying?	Total n=100
Yes	63 (63.0)
No	37 (37.0)
2. For the 37 respondents who answered "No" to the above question (question no. 1), what are the reasons for not using repeatedly heated cooking oil for frying?	Total n=37
Harmful to health	13 (35.1)
Food will look bad	20 (54.1)
Increases cooking oil's cholesterol level	4 (10.8)
3. For the 63 respondents who use the same cooking oil repeatedly for frying, how many times is the cooking oil reused before discarded?	Total n=63
2 times	33 (52.4)
3 times	23 (36.5)
4 times or more	7 (11.1)
4. Source where information was obtained regarding the usage of repeatedly heated cooking oil :	Total n=100
Newspaper	40 (40.0)
Magazine	11 (11.0)
Television	7 (7.0)
Radio	1 (1.0)
Internet	1 (1.0)
Family/Friends/Other people	9 (9.0)
No prior knowledge about this issue	31 (31.0)
5. Do the respondents would like to obtain more information about this issue?	Total n=100
Yes	69 (69.0)
No	31 (31.0)

Table IV: Peroxide Value (PV) of cooking oil samples (n=5 per area) collected from night market food outlets in selected locations of Kuala Lumpur

Selected locations	PV of individual oil samples (mEqO ₂ /kg)	Mean (SD) (mEqO ₂ /kg)
Middle to High Income Areas		
Bangsar	5.30 ^{*,#} 19.26 [*] 29.39 [*] 85.80 135.84	55.12 (54.51)
Taman Tun Dr Ismail	4.51 ^{*,#} 7.84 ^{*,#} 8.24 ^{*,#} 16.48 [*] 20.55 [*] 20.81 [*]	11.52 (6.70) ^a
Titiwangsa	24.59 [*] 29.83 [*] 33.97 40.16	29.87 (7.63)
Bandar Sri Damansara	6.16 ^{*,#} 26.41 [*] 27.60 [*] 42.10 47.66	29.99 (16.17)
Bukit Jalil	23.29 [*] 28.70 [*] 45.21 97.09 176.46	74.15 (64.19)
Sri Petaling	11.76 [*] 13.13 [*] 18.03 [*] 28.81 [*] 51.88	24.72 (16.59)
Bandar Tun Hussein Onn	10.00 ^{*,#} 11.96 [*] 42.22 45.34 47.72	31.45 (18.80)
Setiawangsa	38.87 49.86 53.96 64.73 147.76	71.03 (43.88)
Wangsa Maju	23.71 [*] 38.38 41.38 153.24 214.25	94.19 (84.81) ^a
Taman Maluri	25.30 [*] 26.67 [*] 26.08 [*] 27.06 [*] 27.26 [*]	26.47 (0.80)
Low to Middle Income Areas		
Jalan Klang Lama	3.33 ^{*,#} 4.90 ^{*,#} 5.28 ^{*,#} 67.85 80.54 28.83 [*]	32.38 (38.44)
Kg. Baru	25.30 [*] 27.42 [*] 27.95 [*] 29.00 [*] 35.38	29.00 (3.81)

Selected locations	PV of individual oil samples (mEqO ₂ /kg)	Mean (SD) (mEqO ₂ /kg)
Sentul	6.90 ^{*,#} 17.34 [*] 19.82 [*] 25.30 [*] 35.21	20.91 (10.42)
Kepong	4.90 ^{*,#} 5.49 ^{*,#} 34.41 104.91 127.26	55.40 (57.22)
Pantai Dalam	6.28 ^{*,#} 18.75 [*] 18.93 [*] 21.05 [*] 61.75	25.35 (21.17)

ANOVA test result : F=1.797; P = 0.037

a The mean difference is significant at the 0.05 level (Tukey HSD post-hoc test)

Cooking oil sample safe for human consumption according to AOCs guideline (PV ≤ 10 mEqO₂/kg)

* Cooking oil sample safe for human consumption according to the Food Sanitation Law of Japan Guideline (PV ≤ 30 mEqO₂/kg)

respondents (71.0%) also did not agree that cooking oil can be used many times for frying and only be discarded when it turns dark. Slightly less than half of the respondents (45.0%) agreed that there will be loss of nutrients in the repeatedly heated cooking oil. Less than half (24.0%) of the respondents agreed that the type of cooking oil utilized does not influence the type of by-products produced from the repeatedly heated cooking oil. The majority (69.0%) of the respondents agreed that the usage of repeatedly heated cooking oil is bad for health. Of the 69 respondents who agreed that consumption of repeatedly heated cooking oil is bad for health, more than half of them (43 individuals) said that such practice can lead to the formation of cancer. Other details about the knowledge of the respondents on the usage of repeatedly heated cooking oil are shown in Table II.

Level of knowledge regarding the usage of repeatedly heated cooking oil amongst night market food operators

After scoring was done according to the procedure described in the materials and methods section, it was found that out of the 100 night market food outlet operators who took part in this survey, 18 respondents (18.0%) had low level of knowledge, 53 (53.0%) had moderate level of knowledge and 29 respondents (29.0%) had high level of knowledge. There was no significant association between the night market food outlet operators' educational status and their level of knowledge regarding the usage of repeatedly heated cooking oil ($\chi^2=2.21, p=0.70$).

Attitude and practice regarding the usage of repeatedly heated cooking oil

More than half of the 100 night market food outlet operators (63.0%) admitted that they used cooking oil repeatedly for deep frying food. For the 37 night market operators who did not use cooking oil repeatedly for frying, 20 individuals stated that such practice would make their food look bad and only 13 individuals thought that such practice is harmful to health. Four respondents who did not use cooking oil

repeatedly thought that such practice would increase the cholesterol level of cooking oil. For the 63 night market operators who used cooking oil repeatedly for deep frying, more than half of them (33 individuals) admitted that they never use the oil more than twice, whereas 7 night market operators admitted re-using cooking oil up to four times or more. None of the night market food operators interviewed had heard or followed any official or unofficial guidelines, directives and instructions regarding the proper usage of cooking oil for deep frying food. Our survey of 100 night market food outlet operators showed that newspapers are their main source of information regarding the dangers of using repeatedly heated cooking oil (40.0%); however, 31.0% of them have never heard about this issue before. The majority of our 100 night market food outlet operators (69.0%) wanted to know more about this issue. Other details about the attitude and practice of the respondents regarding the usage of repeatedly heated cooking oil are shown in Table III. There was no significant association between the night market food outlet operators' level of knowledge and their attitude and practice regarding the usage of repeatedly heated cooking oil ($\chi^2=3.05$, $p=0.55$).

Quality of cooking oil used by the night market operators

Altogether 100 individual cooking oil samples were obtained from night market food operators from 20 different areas in Kuala Lumpur. The quality of cooking oil samples that were used by night market operators to fry food was determined by measuring the Peroxide Values (PV) of the sampled oils and the results are listed in Table IV. According to the American Oil Chemists' Society (AOCS) the upper limit of PV for edible oil is 10 mEqO₂/kg¹⁹. In the Food Sanitation Law of Japan Guideline, PV is set to no more than 30 mEqO₂/kg²⁰. Therefore, if we were to abide by the AOCS guideline, then only 18.0% of the cooking oil samples were considered to be fit for human consumption (Table IV). However, if the Food Sanitation Law of Japan Guideline was used as the measurement of edible oil safety, we found that 62.0% of the cooking oil samples could be considered as fit for human consumption (Table IV). The main concern of this part of the study was not to divulge whether there is significant difference (or not) in PV values between different samples obtained from different night market in different areas of Kuala Lumpur. The main concern was to obtain the PV of every sample that we had collected. In doing so, samples which have acceptable PV can clearly be identified. That is why it is pertinent to list all the individual PV of cooking oil samples obtained from the 20 night markets in Table IV. The results showed that the PV of all five samples obtained from Setiawangsa night market exceeded 30 mEqO₂/kg (and therefore could be unsafe for consumption), whereas the PV of individual oil samples obtained from Taman Tun Dr Ismail, Taman Maluri and Kg. Pandan night markets respectively were all found to be below 30 mEqO₂/kg (and therefore could be safe for human consumption) (Table IV). ANOVA results showed that there was significant difference between the PV of cooking oil samples collected from night markets in different parts of Kuala Lumpur ($F=1.797$, $p=0.037$). Tukey HSD post-hoc test confirmed that the difference was between the oil samples taken from Wangsa Maju and Taman Tun Dr. Ismail ($p<0.05$) (Table IV). However, there was no significant association between the night market food outlet operators'

attitude and practice regarding the usage of repeatedly heated cooking oil and the PV of cooking oil samples taken from them ($\chi^2=194.11$, $p=0.33$). There was also no significant association between different income areas (low, middle and high) and the PV of oil samples taken from night markets of those areas ($\chi^2=96.00$, $p=0.45$).

DISCUSSION

The term repeatedly heated cooking (frying) oil has been used interchangeably with thermally oxidized oils or recycled oils. Due to repeated heating, the quality, colour, smell and taste of cooking oil changes due to the formation of polymers and polar compounds. The process of repeated heating will oxidize the lipid content to potentially toxic lipid peroxidation products²¹. The resulting lipid hydroperoxides decomposes to highly cytotoxic products especially aldehydes which are partly absorbed into the systemic circulation^{22,23}. Peroxyl radicals and aldehydes can impart severe damage on membrane proteins and thus capable of inactivating receptors and membrane-bound enzymes²⁴. This study surveyed a representative sample of night market food outlet operators in Kuala Lumpur on their knowledge, attitude and practice regarding the usage of repeatedly heated cooking oil. Since Malaysians are fond of consuming food bought from night markets, the way in which night market food outlet operators handle cooking oil can have major impact on the health of Malaysians.

All night market food outlet operators (100%) surveyed in this study used palm oil for frying. This is not surprising since Malaysia is currently the world's largest producer and exporter of palm oil²⁵. The fact that palm oil is cheaper and widely available in Malaysia also helps in making it a popular choice of cooking oil. This is in concordance with the finding that palm oil is the major source of cooking oil in many developing countries²⁶. Other types of cooking oil such as soy and corn oil are not used at all by the night market food outlet operators surveyed and this might probably be due to the fact that these oils are more expensive. The situation is different in Costa Rica, a developing Latin American country, whereby soy, corn and sunflower oils are the preferred choices even though palm oil costs less. This is brought about by aggressive marketing and advertising campaign by the respective stake-holders, as well as the perception created by these influential industries that their oils are 'healthier' than palm oil²⁷. These perceptions and influences are not that widespread in Malaysia, where there has been a strong and successful government-backed public campaign which promotes the useful health benefits of using palm oil as cooking oil^{28,29}.

A large proportion of the night market food operators surveyed were aware that consumption of repeatedly heated cooking oil is not healthy, even though they don't exactly know why it is so. Their source of information regarding this issue was limited and some of the night market operators had never heard of this issue before. Awareness of this issue is important because it had been shown that degradation due to the re-use of vegetable oils is an independent risk factor for hypertension⁴. However, if the practice of using oil repeatedly for frying is necessary due to economic reasons, then palm oil

would be the better choice. Palm oil seems to be able to withstand being repeatedly heated better than soy oil. Previous studies have suggested that the unique composition of palm oil allows it to withstand heat better than soy oil. Firstly, it is rich in monounsaturated fatty acids (MUFA) but has low level of polyunsaturated fatty acids (PUFA) compared to soy oil³⁰. PUFA is more easily oxidized compared to MUFA³¹. Repeated heating of vegetable oil high in PUFA results in formation of toxic compounds that increased the risk of hypertension, whereas oils that are rich in MUFA such as palm oil and olive oil can better withstand oxidation and formed less degradation products when they are heated⁴. Secondly, palm oil is rich in vitamin E, which may play an important role in its ability to withstand thermal oxidative changes. Inclusion of α -tocopherol to frying oil was found to render PUFA more resistant to oxidation³². Vitamin E, which effectively protects fatty acids in the oil from oxidation, deteriorates after each frying episode³³. Therefore, repeated heating of frying oils destroys the vitamin E content and exposes the fatty acids to oxidation. The vitamin E content of palm oil mainly consists of tocotrienols, while the main vitamin E in soy oil is tocopherols³⁴. Tocotrienols have better antioxidant capacity than tocopherols^{35,36} and this may contribute to the better resistance to oxidative changes due to repeated heating of palm oil. Using palm oil reflects a positive attitude and practice on the part of night market food outlet operators, not only it is economically viable because it is produced locally, but also healthier than soy oil even if repeatedly heated up to five times³⁷.

There is currently no standard guideline to measure the quality of cooking oil used by independent food outlet operators in this country. Therefore, how long and how many times the cooking oil is used by independent food outlet operators before being discarded is not regulated. Nearly two-third of our respondents in the survey re-use cooking oil for frying 2-3 times before discarding it. This is not too bad since all of them used palm oil for frying, which can withstand thermal oxidation quite well, as mentioned above. Some of the night market food operators surveyed used the cooking oil only once, but the oil was used continuously to deep fry food for a long duration of time, which is a bad practice that renders the oil susceptible to thermal oxidation and degradation. For some of the night market food operators, the reason they did not re-use cooking oil was not because of their awareness of the dangers of consuming repeatedly heated cooking oil, but due to their concerns about the physical attractiveness of food if deep fried using re-used oil. For others, the reason that they did not use repeatedly heated oil is because such practice is detrimental to health. Some of them also believe that using repeatedly heated oil can increase the cholesterol level in the oil. Although one of the reasons given is purely cosmetic and the other is farcical, these are indeed positive attitudes to have in terms of disregarding the habit of using repeatedly heated cooking oil. Some of the response given also emphasized the prevalent lack of scientific knowledge amongst night market food outlet operators regarding the real dangers of using of repeatedly heated cooking oil.

There is also lack of knowledge on the proper frying techniques amongst night market food outlet operators. The night market food outlet operators in this survey were asked

whether they followed any official or unofficial (personally made) guidelines when deep frying food using cooking oil, for example, whether they control the oil temperature using a thermometer and how long the oil is heated before they are topped-up, replaced or discarded, in which all of them replied that they did not follow any guidelines at all. This reflects a negative attitude on the part of food outlet operators with regards to the usage of repeatedly heated oil, since they perceived that as long as the colour of the oil looks acceptable, it is alright to use the oil repeatedly and continuously, even to be kept for the next day for frying another batch of food, which is, of course, a very bad practice. Many are not aware that the temperature of frying oil could affect the fat content of fried food. Recommended optimal frying temperatures are around 180–185°C^{38,39}. Frying at lower temperatures will result in longer frying times and lack of crust formation on fried food surface, which would increase the total absorption of fat into the fried food⁴⁰. A higher frying temperature leads to greater oil degradation, thus producing toxic by-products. Oil degradation products can act as surfactants, thus further increasing the fat content of food that is being fried⁴¹. Degraded fat also tends to stick on food due to its increased viscosity. It may also be assumed that cooking oil quality problems could arise in batch frying operations by night market food operators, especially where frying is usually discontinuous and often carried out by relatively unskilled workers. Ideally, standardized frying temperature should be recommended to and adhered by all food operators. By ensuring every food operator possesses and makes use of a frying thermometer and providing a definitive guideline on frying temperature that has to be complied by food operators could potentially improve the health of the general public.

Cooking oil turnover is an important determinant of cooking oil quality¹³. If the cooking oil that is already being used for frying is frequently replenished with new cooking oil, the old oil will be diluted and the resulting oil mixture will look fresh and its shelf life will be extended⁴¹. Some of the night market food operators we surveyed claimed they did not re-use the same oil for frying food for the next day, but we were not sure whether they practice the act of replenishing older frying oil with fresh oil on the same frying day, as the day goes on. The practice of replenishing cooking oil by partial replacement with fresh oil, rather than totally replacing all the fat at once, is associated with significantly elevated levels of oil degradation products which can be carcinogenic¹⁷. This is a good reason why a standard regulation on food-frying techniques should be imposed on food operators in this country. Cooking oil quality test kits that can adequately measure cooking oil quality are routinely used by fast-food chain outlets in Malaysia. In order to further improve the health of Malaysians, we would like to suggest that these cooking oil quality test kits also be randomly tested on cooking oil used by night market food operators, and those found using oil of unsuitable quality (i.e. excessively repeatedly heated cooking oil) should be educated on the proper usage of cooking oil.

Another important issue is how to judge whether deterioration of the cooking oil has reached the point at which it needs to be discarded. In the food industry setting where there are proper back-up laboratory facilities (especially

in developed countries), the used cooking oil could be tested for definitive change in colour, free fatty acids, total polar materials, polymeric triglycerides and ultraviolet absorption (for the estimation of conjugated dienes)⁴². However, it is not practical to test for these parameters in the field (e.g. at the night market setting) and the cost of implementing such tests could be a huge financial burden for a developing country like Malaysia. In order to simplify matters, it had been suggested that several criteria can be observed on-site in order to measure the quality of cooking oil². The criteria include observations regarding the crude colour of oil, foaming, appearance of smoke, odour of frying oil, length of time used and sensory (taste) evaluation of the resultant fried food².

The Peroxide Value (PV) is a useful measure of oil quality. The PV is one of the most frequently determined quality parameters during oil production, storage and marketing. It is an index to quantify the amount of hydroperoxide in fats and oils²⁰. Hydroperoxide is formed by the oxidation of fats and oils. PV therefore indicates the degree of oxidation in the substance and measures the amount of total hydroperoxides as a product of primary oil oxidation⁴³. When cooking oil is heated, the PV rises. However, peroxides are also rapidly decomposed at high temperatures. It has been reported that weakly oxidized fats and oils at levels of only 100 mEqO₂/kg of PV can be neurotoxic⁴⁴. Therefore, it is of utmost importance that the quantity of hydroperoxides in cooking oil remains low so that the safety of fried food is not compromised.

Currently, there is no consensus cut-off point for PV of cooking oil that is agreed by all countries in the world. The American (AOCS) PV cut-off point is only lower by 20 mEqO₂/kg than the Japanese cut-off point, simply because the AOCS would want to prevent the existence of lipid hydroperoxides in their oil as much as possible. In our opinion, the Japanese cut-off point for PV in oils and fats is more realistic because it was backed by both human (epidemiological) and animal studies. Instant noodles are fried food, and therefore contain lots of fats and oils. In the early 1960s, Japan had a few food poisoning epidemic caused by the degradation of fats and oils in instant noodles. Many people who ate the degraded instant noodles developed acute symptoms such as diarrhea, nausea, emesis, abdominal pain, fatigue and headache. These symptoms are strongly related to the central nervous system. However, no death was reported. Laboratory tests done on the deteriorated instant noodle samples showed that the mean PV values of the deteriorated instant noodles was around 100 mEqO₂/kg. After the incidents, the Japanese authorities began to set certain standards for instant noodles in their Food Sanitation Law to protect against food poisoning and to control the quality of instant noodles. In that law, peroxide value (PV) was chosen as one of the index to control food safety and quality, and the standard PV was set at no more than 30 mEqO₂/kg. This value was chosen because it experimentally indicates the initial stage of fat and oil deterioration *in vitro*. After setting this value, there have been no reported cases of food poisoning caused by instant noodles in Japan⁴⁵. PV of 100 mEqO₂/kg might not be very high, but animal studies that have since been done revealed that this level of deteriorated fat and oil is neurotoxic. Rats that ate deteriorated fats and oils with a PV

of at least 107.2 mEqO₂/kg had significantly decreased locomotor activity compared to control rats. These phenomena suggested that oxidized fats and oils with PV of at least 100 meq/kg induced neurotoxicity⁴⁴. During oxidation of fats and oils, a sudden surge in oxidation occurs during the propagation phase of the oxidative process after the induction period, once all the antioxidants contained in the fats and oils have all been used up. Although 30 mEqO₂/kg is much less than 100 mEqO₂/kg, once the sudden oxidation is initiated during the propagation period of lipid peroxidation, the 100 mEqO₂/kg level would easily be reached soon after the 30 mEqO₂/kg threshold level was noted in the oils. Consequently, setting a criterion of 30 mEqO₂/kg as the maximal PV in fats and oils is important to control food safety. One of the most effective ways in order to achieve this is by not using repeatedly heated cooking oil.

After measuring the PV of cooking oil samples obtained from various night markets in Kuala Lumpur, we found that more than half of the oils (62%) are within the safe limits of consumption (PV ≤ 30 mEqO₂/kg). However, it should be reiterated that the PV measured in the laboratory on used cooking oil most probably reflects the oxidation occurring in the time frame between sampling and analysis, and does not truly reflect the value of hydroperoxides in real-time setting where the oil is actually being used for frying food at the night market *in-situ*⁴². PV values also differ widely according to the type of food that is deep fried⁴⁶. PV values of oils can be very low after deep frying fruits, tubers, vegetables and other plant-based products such as potato chips. PV values of oils can be very high after deep frying meat-based products such as fried chicken, keropok lekor, fish cakes and sausages. The different brands of oils used by different outlets, the types of oil used (packaged recycled palm oil as opposed to fresh palm oil), deep frying temperature, the duration of deep frying, deep frying pattern (continuous or intermittent) and the type of utensils used for frying also have very great impact on the PV of cooking oils after frying food⁴⁶. These various factors were thought to contribute to the huge difference in the PV of cooking oil samples that were used for deep frying that we have collected from various night market food outlets. Due to the various factors that could affect PV value of oils used for deep frying, extreme caution should be made when interpreting the laboratory-based PV results that were obtained in this study.

Due to the huge variation in the PV of our oil samples, the only significant difference in PV was found in the oil samples obtained from Wangsa Maju and Taman Tun Dr. Ismail night markets. It might be tempting to assume that the night market food operators in Taman Tun Dr. Ismail night market have better knowledge, attitude and practice regarding the proper usage of cooking oil compared to those in Wangsa Maju. However, due to the various factors that could affect PV of oils during and after deep frying, it is hard to determine the actual reasons why the PV of oil samples taken from Wangsa Maju night market was significantly higher than that of Taman Tun Dr. Ismail night market. It could be that the oil samples taken from night market in Taman Tun Dr. Ismail were mainly from stalls that deep fry plant-based food and oil samples taken from Wangsa Maju were mainly from stalls that deep fry meat-based food. This was because during the

oil samples collection, we did not differentiate between food outlets that sell plant-based fried food and meat-based fried food. We also did not take into account the different brands of oils used by different outlets, the types of oil used (packaged recycled palm oil as opposed to fresh palm oil), deep frying temperature, the duration of deep frying, deep frying pattern (continuous or intermittent), whether the food operators replenish their oil during their frying sessions and the type of utensils used for frying when we were collecting our samples. In order to make the result more meaningful, further studies should consider all these factors when determining the difference in PV of oils used for deep frying that are obtained from various food outlets. Additionally, also probably due to these factors, we did not find any significant association between different income areas (low, middle and high) and the PV of oil samples taken from night markets of those areas. The lack of association between different income areas and PV of oils collected from those areas might also be due to the fact that the night market outlet operators are a heterogeneous lot in terms of their awareness on the proper ways of deep frying and the usage of repeatedly heated cooking oil.

During the survey, the night market food outlet operators were asked whether they would like to obtain more information on this subject matter, which includes the proper ways to use cooking oil for deep frying as well as the detrimental effects of using repeatedly heated cooking oil, in which more than half of the respondents said that they would like to, which is a good attitude to have in terms of improving one's knowledge in healthy behaviour. Their attitude in seeking information about the usage of repeatedly heated cooking oil were also tested by asking if they had previously known that using cooking oil repeatedly for frying food is not a healthy practice, in which the majority of the respondents said that they had obtained such information from reading the newspapers. This also indicated that their attitude towards using repeatedly heated cooking oil might be affected by the information that they received from the newspapers, although it might not necessarily translate into good practice of using cooking oil. However, we also discovered that a considerable percentage (31.0%) of the night market food operators surveyed in this study were totally unaware of this issue. This corresponds to the percentage (30.0%) of night market food operators surveyed in this study which received only primary education or no education at all. Therefore, apart from awareness campaign in the mass media, which might not reach the uneducated night market operators, health officials and personnel should go to the field and educate about this issue individually to night market operators, especially to those who are not inclined to read newspapers or follow other popular mass media.

The results showed that there is no significant association between the night market food operators' knowledge and attitude and practice, attitude and practice and PV of oil samples taken from them, as well as between the night market food operators' educational level and their knowledge regarding the usage of repeatedly heated cooking oil. It is therefore highly pertinent to further improve their knowledge and translate that into positive changes in their attitude and practice regarding usage of repeatedly heated cooking oil. In order to improve knowledge, more awareness

campaign about this matter should be highlighted in the mass media. Public health officials should go to the field and educate the night market food operators individually about the perils of using repeatedly heated cooking oil. These measures would address the prevalent lack of scientific knowledge amongst night market food outlet operators regarding the real dangers of using of repeatedly heated cooking oil. In order to change practice, voluntary training on the proper techniques of deep frying food should be given to these food operators in government funded vocational schools that provide catering courses. Government food inspectors should advice night market food outlet operators that deep fried food should be drained from the frying oil as much as possible by shaking off excess oil when taking the fried food out of the fryer, and placing the fried food on absorbent paper towels to absorb additional excess oil for at least a few minutes before selling. Each night market food outlet that practice deep frying should have a suitable cooking thermometer so that frying temperature can be controlled. The food inspectors should also discourage food operators from replenishing cooking oil by partial replacement with fresh oil, rather than totally replacing all the oil at once, when they notice that the oil has changed colour during long frying sessions. Oil should be filtered regularly using filter aids during daily frying sessions in order to maintain the good quality of frying oil. However, the best advice given would always be not to use today's frying oil for next day's frying sessions.

There were some limitations in this study with regards to knowledge, attitude and practice of night market food outlet operators as convenience sampling was done in order to obtain our respondents for the survey due to time and financial constraints. The data obtained on knowledge, attitude and practice regarding usage of repeatedly heated cooking oil would have been more concrete if more night market food outlet operators were identified within a targeted population that had been specifically selected and further stratified according to their socioeconomic standing, educational and health status. More information regarding healthy eating practices and behaviours of the night market food outlet operators would have added greatly to the variables that suggest health awareness. It is also difficult to interpret associations regarding race since the majority of the respondents were Malays. Other factors relating to lifestyle or health awareness (frequency of exercise, reported history of having chronic diseases such as diabetes or hypertension, as well as smoking status) which we did not take into account in this study may also be important determinants with regards to the practice of using repeatedly heated cooking oil amongst the night market food outlet operators. There are also several limitations associated with our PV results. We did not take into account the different types of foods that were being fried at different outlets when we collected the oil samples. In other words, we did not differentiate between outlets that only sell deep fried plant-based products from outlets that sell only deep fried meat-based products when we collected our oil samples for PV testing. As stated before, the PV of oil samples after frying plant-based products is very much lower than the PV of oils after frying meat-based products. This could explain the big difference in PV amongst our samples. We also did not take into account the frying temperature used in different outlets, how big the flame of

the gas cooker was in different outlets, the length of each frying sessions in different outlets, the different styles of deep frying (continuous or intermittent frying) employed by different outlets, the different types of utensils used for deep frying in different outlets, the different types of oil used (packaged recycled palm oil or fresh palm oil) by different outlets or whether the food outlet operators replenished their oils regularly during their daily frying sessions. All of these factors contributed to the huge difference in PV of oils samples obtained from different food outlets.

Deep fried foods are well-liked by consumers due to their taste, smell and texture. Frying is also one of the easiest and cheapest ways of cooking, thus making it a popular choice especially for the lower income group. Even though a certain amount of potentially toxic products are produced during frying (such as polar compounds or polymers), fried foods are generally considered safe⁴⁷. It is only when frying oil is used repeatedly that it becomes toxic for human consumption⁴. According to a study done in Japan, the recovered oil (repeatedly used/heated oil) that has been used to deep fry food was still safe to use after deep frying was done at 180°C for 3 hours a day for 5 consecutive days. However, the same conclusion could not be made of the foodstuff that had been deep fried with such oil. The researchers found that the oil within the batter coatings of 4% of deep fried food (that was fried using the repeatedly heated cooking oil) had high acidic value content (which can affect food quality), and 4-22% of the oil trapped in the batter coating also had properties worse than those of the repeatedly heated cooking oil. The authors of that study therefore concluded that the best way to ensure the safe use of cooking oil would be to shorten its usage span⁴⁸. This strengthens our position on not encouraging the usage of repeatedly heated cooking oil to fry food.

CONCLUSION

The level of knowledge of the night market food outlet operators in Kuala Lumpur regarding the usage of repeatedly heated cooking oil needs to be improved. More publicity and exposure about this little-known health issue to food outlet operators should be given in the mass media and also through individual one-to-one encounters. Awareness campaigns relating to this little-known health issue that targets night market food outlet operators should be carried out by the relevant health authorities. Further episodes of field studies should be executed in order to measure the actual level of toxic and polar compounds that could be found in frying oils used by night market food outlet operators, apart from just measuring the PV of the cooking oil. A follow-up prospective cohort study is also warranted in order to observe whether there are positive changes in the behavior and knowledge of the night market food operators that had been surveyed and educated regarding the usage of repeatedly heated cooking oil.

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